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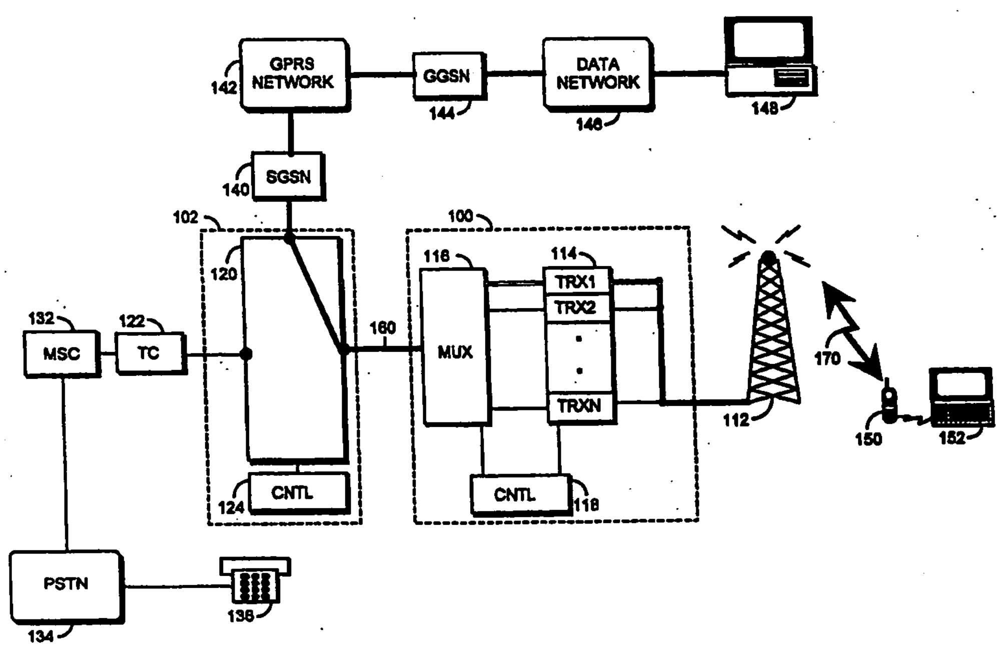
(54) Title: DATA TRANSMISSION METHOD AND BASE STATION SYSTEM

(57) Abstract

The invention relates to a data transmission method in a base station system of a cellular radio network. The base station system comprises base stations (100) and one base station controller (102). Between the base station (100) and the base station controller (102), circuit–switched data is transferred bi–directionally on a circuit–switched transmission connection (160). According to the invention, a circuit–switched transmission connection (160) not in use in circuit–switched data transmission is used for transmitting packet–switched data and packet–switched signalling. Data is advantageously transferred on the circuit–switched transmission connection (160) in TRAU frames (Transcoder and Rate Adapter Unit) formed for transcoding. Packet transmission is advantageously carried out by using GPRS (General Packet Radio Service). The transmission of packet–switched data and packet–switched signalling is synchronized in both transmission directions by using a control loop of the circuit–switched transmission connection (160) between the base station (100) and the base station controller (102).



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DATA TRANSMISSION METHOD AND BASE STATION SYSTEM

FIELD OF THE INVENTION

The invention relates to a data transmission method in a base station system of a cellular radio network, the base station system comprising at least one base station and one base station controller, circuit-switched data being bi-directionally transmitted on a circuit-switched transmission connection between the base station and the base station controller.

BACKGROUND OF THE INVENTION

In addition to circuit-switched transmission of speech and data, there is an increasing need for packet-switched data transmission in cellular radio networks. New solutions have been developed in order to allow existing cellular radio networks to be changed to enable them to provide packet transmission as advantageously and efficiently as possible.

GPRS (General Packet Radio Service) is a new GSM-based service, in which air interface capacity not in use in circuit-switching is used for packet transmission.

A kind of a bottleneck that remains is the transmission of packet-switched data and packet-switched signalling between a base station and a base station controller. A solution that has been suggested is to carry out the transmission using a separate data transmission connection. Operators, however, do not find this solution very attractive because it causes permanent additional costs of operation.

Since circuit-switched signalling is performed using a specific signalling channel,. it has also been suggested that packet transmission and packet-switched signalling could be carried out using the free capacity of the signalling channel concerned. The signalling channel in question can be referred to as a LAPD channel, for example, according to the protocol used. A problem, however, is that for one transceiver, or eight traffic channels, there is usually one LAPD channel of 16 kbit/s in use, and from this capacity hardly any remains to be used for packet transmission and packet-switched signalling. There are also solutions in which for instance the signalling of five transceivers is conveyed on one 64 kbit/s channel. Even when not in use in circuit-switching signalling, the capacity of an LAPD channel is not very high.

One possibility would be to increase the speed of the LAPD channel in question from 16 kbit/s to 64 kbit/s, the capacity for packet transmission

then being perhaps 50 kbit/s. Again, however, costs cause a problem: the solution causes to the operator fixed and permanent additional costs not depending on the use of packet transmission. In the worst case, the 2 Mbit/s PCM link the operator uses for the transmission is so full that the proposed increase in capacity would require a new PCM link to be taken in use. This is not only expensive, but also inconvenient.

BRIEF DESCRIPTION OF THE INVENTION

An object of the invention is thus to provide a method and an equipment implementing the method so as to allow the above problems to be solved. This is achieved with a method of the invention, characterized in that a circuit-switched transmission connection not in use in circuit-switched data transmission is used for transmitting packet-switched data and packet-switched signalling.

The invention also relates to a cellular radio network base station system comprising at least one base station and one base station controller, the base station and the base station controller being arranged to bi-directionally transmit between them circuit-switched data on a circuit-switched transmission connection.

The base station system according to the invention is characterized in that the base station and the base station controller are arranged to transmit between them packet-switched data and packet-switched signalling on a circuit-switched transmission connection not in use in circuit-switched data transmission.

The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the adaptability between circuit-switched and packet-switched data transmission over an air interface being also utilized in an Abis interface between the base station and the base station controller. When the air interface has free channels available for packet transmission, the Abis interface also has, at the same time, circuit-switched transmission capacity available for packet transmission and packet-switched signalling.

A method and arrangement of the invention provide several advantages. The capacity not in use in circuit-switched data transmission can be optimally utilized. New data transmission capacity is not needed between the base station and the base station controller, so the network operator saves on investment and/or operational costs. The invention allows, as will be

described below, clearly higher transmission rates to be obtained than by using the LAPD channel. The transmission connection is reliable because synchronisation has already been confirmed before the transmission starts.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail in connection with preferred embodiments and with reference to the attached drawings, in which

Figure 1 is a block diagram illustrating a cellular radio network;
Figure 2 illustrates a structure of a transceiver;
Figure 3 illustrates Abis interface channels;
Figure 4 illustrates a structure of a TRAU frame;
Figure 5 illustrates a standard circuit-switched call;
Figure 6 illustrates packet-switched data transmission.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Figure 1, a typical cellular radio network structure of the invention and its interfaces to a fixed telephone network and packet-switched network will be described. Figure 1 only comprises the blocks that are essential for the description of the invention, although it is apparent to a person skilled in the art that a common cellular radio network also comprises other functions and structures which need not be discussed in greater detail here. The invention is suited for use in basic GSM cellular radio networks and in networks developed from it, such as GSM1800 and GSM1900 systems. The invention is most advantageously used in a GSM phase 2+ packet transmission, i.e. in the GPRS (General Packet Radio Service).

A cellular radio network typically comprises a fixed network infrastructure, i.e. a network part, and subscriber terminals 150, which may be fixedly mounted, vehicle mounted or hand-held portable terminals. The network part comprises base stations 100. A plural number of base stations 100 are, in turn, controlled in a centralized manner by a base station controller 102 communicating with them. A base station 100 comprises transceivers 114. A base station 100 typically comprises 1-16 transceivers 114. A transceiver 114 offers radio capacity to one TDMA frame, i.e. typically to eight time slots.

The base station 100 comprises a control unit 118 which controls the operation of the transceivers 114 and a multiplexer 116. The multiplexer 116 arranges the traffic and control channels used by a plural number of transceivers 114 to a single transmission connection 160. The structure of the

transmission connection 160 is determined in detail and it is referred to as an Abis interface. The transmission connection 160 is typically implemented using a 2 Mbit/s connection, i.e. a PCM link (Pulse Coded Modulation) providing a transmission capacity of 31 x 64 kbit/s, time slot 0 being allocated to synchronization. The structure of the Abis interface and the implementation of the transmission connection will be discussed in greater detail later, in connection with Figures 3 and 4.

The transceivers 114 of the base station 100 have a connection to an antenna unit 112 which is used for providing a bi-directional radio connection 170 to a subscriber terminal 150. The structure of the frames transmitted in the bi-directional radio connection 170 is also determined in detail and the connection is referred to as an air interface.

The subscriber terminal 150 can be for instance a standard GSM mobile phone which can be connected, by means of an additional card, to a portable computer 152, for example, that can be used in packet transmission for ordering and processing of packets.

Figure 2 illustrates in greater detail the structure of a transceiver 114. A receiver 200 comprises a filter blocking frequencies outside a desired frequency band. A signal is then converted to an intermediate frequency or directly to baseband, and in this form the signal is sampled and quantized in an analog-to-digital converter 202. An equalizer 204 compensates for interference caused for instance by multi-path propagation. From the equalized signal, a demodulator 206 takes a bit stream, which is transmitted to a demultiplexer 208. The demultiplexer 208 separates the bit stream from the separate time slots into its logical channels. A channel codec 216 decodes the bit stream of the separate logical channels, i.e. decides whether the bit stream is signalling data, which is transmitted to a control unit 214, or whether the bit stream is speech, which is transmitted to a speech codec 122 of the base station controller 102. The channel codec 216 also performs error correction. The control unit 214 performs internal control functions by controlling different units. A burst former 228 adds a training sequence and a tail to the data arriving from the speech codec 216. A multiplexer 226 assigns to each burst its time slot. A modulator 224 modulates digital signals to a radio frequency carrier. This operation has an analog nature, therefore a digital-to-analog converter 222 is needed for performing it. A transmitter 220 comprises a filter restricting the bandwidth. In addition, the transmitter 220 controls the output

power of a transmission. A synthesizer 212 arranges the necessary frequencies for the different units. The synthesizer 212 comprises a clock which may be locally controlled or it can be centrally controlled from somewhere else, for instance from the base station controller 102. The synthesizer 212 creates the necessary frequencies by means of a voltage controlled oscillator, for example.

The base station controller 102 comprises a group switching field 120 and a control unit 124. The group switching field 120 is used for switching speech and data and for connecting signalling circuits. The base station 100 and the base station controller 102 form a base station subsystem which additionally comprises a transcoder, also known as a speech codec, or TRAU (Transcoder and Rate Adapter Unit) 122. The transcoder 122 is usually located as close to a mobile switching centre 132 as possible because this allows speech to be transmitted between the transcoder 122 and the base station controller 102 in a cellular radio network form, which saves transmission capacity.

The transcoder 122 converts different digital speech coding modes used between a public switched telephone network and a cellular radio network, to make them compatible, for instance from the 64 kbit/s fixed network form to another form (such as 13 kbit/s) of the cellular radio network, and vice versa. The control unit 124 carries out call control, mobility management, collection of statistical data and signalling.

As shown in Figure 1, the group switching field 120 can be used to perform switching (depicted with black spots) both to a Public Switched Telephone Network (PSTN) 134, via the mobile switching centre 132, and to a packet network 142. In the public switched telephone network 134 a terminal 136 typically is an ordinary telephone or an ISDN phone (Integrated Services Digital Network).

The connection between the packet network 142 and the group switching field 120 is created by a support node 140 (SGSN = Serving GPRS Support Node). The function of the support node 140 is to transfer packets between the base station system and a gateway node (GGSN = Gateway GPRS Support Node) 144 and to keep record of the subscriber terminal's 150 location within its area.

The gateway node 144 connects the packet network 142 and a public packet network 146. The interface can be provided by an Internet

protocol or an X.25 protocol. The gateway node 144 encapsulates the internal structure of the packet network 142, thus hiding it from the public packet network 146, so for the public packet network 146 the packet network 142 looks like a sub-network, and the public packet network can address packets to a subscriber terminal 150 located in the sub-network and receive packets from it.

A typical packet network 142 is a private network applying an Internet protocol and conveying signalling and tunnelled user data. The structure of the network 142 can vary according to operator, both as regards its architecture and its protocols below the Internet protocol layer.

The public packet network 146 can be for instance a global Internet network into which a terminal 148, for instance a server, with a connection to the network wants to transmit packets addressed to the subscriber terminal 150.

Figure 3 illustrates channels of the Abis interface 160, i.e. logical channels used for bi-directional data transmission between the base station 100 and the base station controller 102. The base station 100 of the example comprises two transceivers 114. Since one transceiver 114 provides radio capacity for eight air interface time slots, the example shown in Figure 3 comprises two times eight traffic channels T0, T1, ..., T7 of 16 kbit/s each. Time slot 0 of a first transceiver 114 is typically not used for transmission of speech because it is the time slot used for transmitting a BCCH control channel (Broadcast Control Channel). In the Abis interface 160 time slot T0 is, however, allocated although it is not used. Both transceivers 114 have one 16 kbit/s signalling channel S1, S2 available. The signalling channels S1, S2 can also be referred to as LAPD channels.

According to prior art, packet-switched transmission in the Abis interface 160 would be performed either using the signalling channels S1, S2 as such or enlarged to 64 kbit/s. Another option would be to dedicate a particular transmission path for the packet transmission connection or to use the capacity possibly available in the PCM link. The earlier mentioned drawbacks would be involved: slow speed of transmission, costs caused by additional capacity or, possibly, major expenditure due to a new PCM link.

In the air interface 170 packet transmission is provided by using time slots not allocated to circuit-switched transmission. Packet transmission capacity is dynamically allocated, so when a data transmission request arrives,

any free channel can be allocated to packet transmission. The arrangement is a flexible one, circuit-switched connections having a priority over packet-switched connections. When necessary, circuit-switched transmission cancels packet-switched transmission, i.e. a time slot engaged in packet transmission is allocated to circuit-switched transmission. This is possible because packet transmission tolerates such interruptions well: the transmission is simply continued on another time slot allocated for use. The arrangement can also be implemented in such a way that no absolute priority is given to circuit-switched transmission, but both circuit-switched and packet-switched transmission requests are served in their order of arrival.

According to the invention, the dynamic allocation of the air interface 170 is also utilized in the Abis interface 160. When the air interface 170 has a time slot not allocated to circuit-switched transmission, then the Abis interface 160 also has circuit-switched transmission connection capacity, corresponding to the time slot in question, that is not allocated to circuit-switched transmission. The circuit-switched transmission connection capacity available in the Abis interface 160 can thus be used for a bi-directional transmission of packet-switched data and packet-switched signalling between the base station 100 and the base station controller 102. Like the air interface 170, the nature of packet-switched transmission in the Abis interface 160 is also flexible: when necessary, circuit-switched transmission cancels packet transmission.

Let us assume, by way of example, that the time slots framed in bold print in Figure 3, i.e. time slots T1, T2, T3, T5 and T7 of a first transceiver TRX1 and time slots T0 and T3 of a second transceiver TRX2 are allocated to a circuit-switched connection. The rest of the capacity, i.e. three time slots in TRX1 and six time slots in TRX2 are available to be allocated to the transmission of packet-switched data and packet-switched signalling. At its maximum the transceiver 114 could of course have all, i.e. eight, time slots available for packet transmission. In theory, the capacity would then be 8 x 16 kbit/s, i.e. 128 kbit/s. In practice the capacity is a little less due to identifying data (such as transaction identifier data and sequence number) needed for segmentation and desegmentation being added to the time slots.

Figure 4 illustrates how the data of the time slots are usually arranged in the Abis interface into the TRAU (Transcoder and Rate Adapter Unit) frames formed for transcoding. In the subscriber terminal 150, 260 bits

containing 20 ms of speech are coded, the most important 50 class Ia bits and 132 class Ib bits being convolution coded. In addition, error correction bits are added, whereby 378 bits are obtained in total. To the 378 bits are added 78 less important class II bits. A total of 456 bits which would, in principle, fit into four radio bursts are thus obtained. However, for safety, they are spread into eight radio bursts as sub-bursts of 57 bits. Each burst is sent at an interval of 577 microseconds.

The transmitted speech bits are collected from the eight successive bursts in the channel codec 216. The convolution coding is decoded and the original 260 speech containing bits are placed in a TRAU frame.

The values of bits 0-15 of a TRAU frame are always zero so that successive TRAU frames are distinguished from one another. The least significant 0 bit of every following word 1-19 is always a synchronization bit having the value 1.

The original 260 bits received over the air interface are placed in bits 1-15 of TRAU frame words 2-18 and in bits 1-5 of word 19.

In the channel codec 216 are also set the values of control bits C1-C21 located in bits 1-15 of word 1 and in bits 6-11 of word 19. In addition, timing bits T1-T4 located in bits 12-15 of word 19 are set in the channel codec 216.

For a packet transmission according to the invention, the 260 bits denoted with a letter P in Figure 4 are available. Possibly 240 of these bits, or 30 bytes, could be used, in the above described manner, for transmission of payload. This provides the 12 kbit/s transmission rate per time slot already mentioned.

Packet-switched data and packet-switched signalling could also be transmitted using frames of an optimised structure. This would allow a slightly higher transmission rate to be obtained. On the other hand, when standard TRAU frames are used, the solution of the invention is better compatible with existing base station systems.

Let us now examine, with reference to Figures 5 and 6, how a base station system of the invention functions. As all the structural parts shown in Figures 5 and 6 appear in Figure 1 and are described in connection with it, the description will not be repeated here.

Figure 5 illustrates how a circuit-switched transmission connection is created between the subscriber terminal 150 and the public switched

telephone network terminal 136. In the Figures, a thicker line illustrates data travelling through the system over the air interface 170 from the antenna 112 to the transceiver 114, and from there, multiplexed in the multiplexer 116, on the circuit-switched transmission connection 160 to the group switching field 120, where a connection to an output to the transcoder 122 is generated, and from there, on a connection established in the mobile switching centre 132, to the public switched telephone network 134 providing a connection to the terminal 136. The control unit 118 at the base station 100 controls the multiplexer 116 to carry out the transmission, the control unit 124 at the base station controller 102 controlling the group switching field 120 to provide the right switching. Data travels in a transparent form bi-directionally from the channel codec 216 to the transcoder 122, a control loop ensuring synchronization being thereby formed.

In Figure 6 we have proceeded to a situation in which the circuit-switched transmission connection 160 used in Figure 5 is released from the transmission of circuit-switched data. To the subscriber terminal 150 is now connected a portable computer 152. A thicker line depicts how data to be transmitted travels from the server 148 to the portable computer 152. Data can naturally also be transmitted in the reverse transmission direction, i.e. from the portable computer 152 to the server 148. The data is conveyed through the system over the air interface 170 from the antenna 112 to the transceiver 114 and from there, multiplexed in the multiplexer 116, on a circuit-switched transmission connection 160 free of circuit-switched data transmission to the group switching field 120 where a connection is established to the output to the support node 140, the data being conveyed from the support node 140 on the packet network 142 through the gateway node 144 to the public packet network 146 providing a connection to the server 148.

In Figure 5 circuit-switched transmission uses a single time slot, whereas in Figure 6 the free capacity of the circuit-switched transmission connection 160 corresponding to all time slots available in the air interface 170 can be used. As described above, the capacity can be arranged as TRAU frames. For the sake of clarity, Figures 5 and 6 do not show a case in which both circuit-switched and packet-switched data would be simultaneously transmitted. This is, however, fully possible and represents in fact the most common implementation of the invention, because capacity not in use in circuit-switched data transmission can be flexibly taken in use for packet-

switched transmission or packet-switched signalling. It is also possible to build a network in which circuit-switched data is not transmitted in the network at all, but only packet data. This allows the network structure to be simplified.

The use of a packet transmission according to the invention provides different options for the management of the control loop. For example, a single base station controller 102 can have as many as 380 transceivers 114 to be managed. This means that 380 x 8 = 3040 parallel loops have to be managed. In theory the management could be assigned to the support node 140. It is, however, more rational to terminate the loops already at the base station controller 102. A possible solution is to have a separate processor card (not shown in the Figures) at the base station controller 102 for each PCM link 160, the processor card being able to process the control loops of for instance 12-15 separate transceivers 114. In addition to control loop management, the processor cards in question then separate packet data from the incoming traffic for transmission to the support node 140.

The described control loop method makes the initial synchronization of packet transmission extremely easy; in practice, it is not needed because the transmission units are already synchronized by the control loop. An advantage this provides is faster operation. In addition, the reliability of packet transmission increases significantly when, at the beginning of a transmission, there is no risk of the initial synchronization failing and thus causing data to be corrupted.

The invention is advantageously implemented by software, the invention then requiring relatively simple software changes within a strictly limited area in the control unit 118 of the base station 100 and in the control unit 124 of the base station controller 102. The group switching field 120 must also be as described, thus allowing time slots to be connected to the transcoder 122 or to the support node 140.

Although the examples only show a point-to-point packet transmission connection between two parties, the invention is in no way restricted to it, but it is apparent to a person skilled in art how the described arrangement can also be used for instance in point-to-multipoint connections where one party simultaneously broadcasts data to a plural number of other parties. The connection does not need to be bi-directional either; although the invention allows bi-directional connections, a connection can also be a uni-directional broadcast where the sender receives no acknowledgement from

the receiver for the reception of a transmission. Different combinations are also possible, such as a point-to-multipoint broadcast.

Even though the invention is described above with reference to an example shown in the attached drawings, it is apparent that the invention is not restricted to it, but can vary in many ways within the inventive idea disclosed in the attached claims.

CLAIMS

1. A data transmission method in a base station system of a cellular radio network, the base station system comprising at least one base station (100) and one base station controller (102), circuit-switched data being bi-directionally transmitted on a circuit-switched transmission connection (160) between the base station (100) and the base station controller (102), **characterized** in that a circuit-switched transmission connection (160) not in use in circuit-switched data transmission is used for transmitting packet-switched data and packet-switched signalling.

2. A method according to claim 1, **characterized** in that on the circuit-switched transmission connection (160), data is transmitted in TRAU frames (Transcoder and Rate Adapter Unit) formed for transcoding.

3. A method according to claim 1, **characterized** in that packet transmission is carried out by using GPRS (General Packet Radio Service).

4. A method according to claim 1, **characterized** in that the circuit-switched transmission connection (160) is dynamically allocated to the transmission of packet-switched data and packet-switched signalling.

5. A method according to claim 1, **characterized** in that the transmission of packet-switched data and packet-switched signalling is synchronized in both transmission directions by using a control loop of the circuit-switched transmission connection (160) between the base station (100) and the base station controller (102).

6. A method according to claim 2, **characterized** in that packet-switched data and packet-switched signalling are transmitted by using frames of a standard TRAU structure.

7. A method according to claim 2, **characterized** in that packet-switched data and packet-switched signalling are transmitted by using frames of an optimized structure.

8. A cellular radio network base station system comprising at least one base station (100) and one base station controller (102), the base station (100) and the base station controller (102) being arranged to bi-directionally transmit between them circuit-switched data on a circuit-switched transmission connection (160), **characterized** in that the base station (100) and the base station controller (102) are arranged to transmit between them packet-switched data and packet-switched signalling on a circuit-switched

transmission connection (160) not in use in circuit-switched data transmission.

9. A base station system according to claim 8, **characterized** in that the base station system is arranged to transmit data on the circuit-switched transmission connection (160) in TRAU frames (Transcoder and Rate Adapter Unit) formed for transcoding.

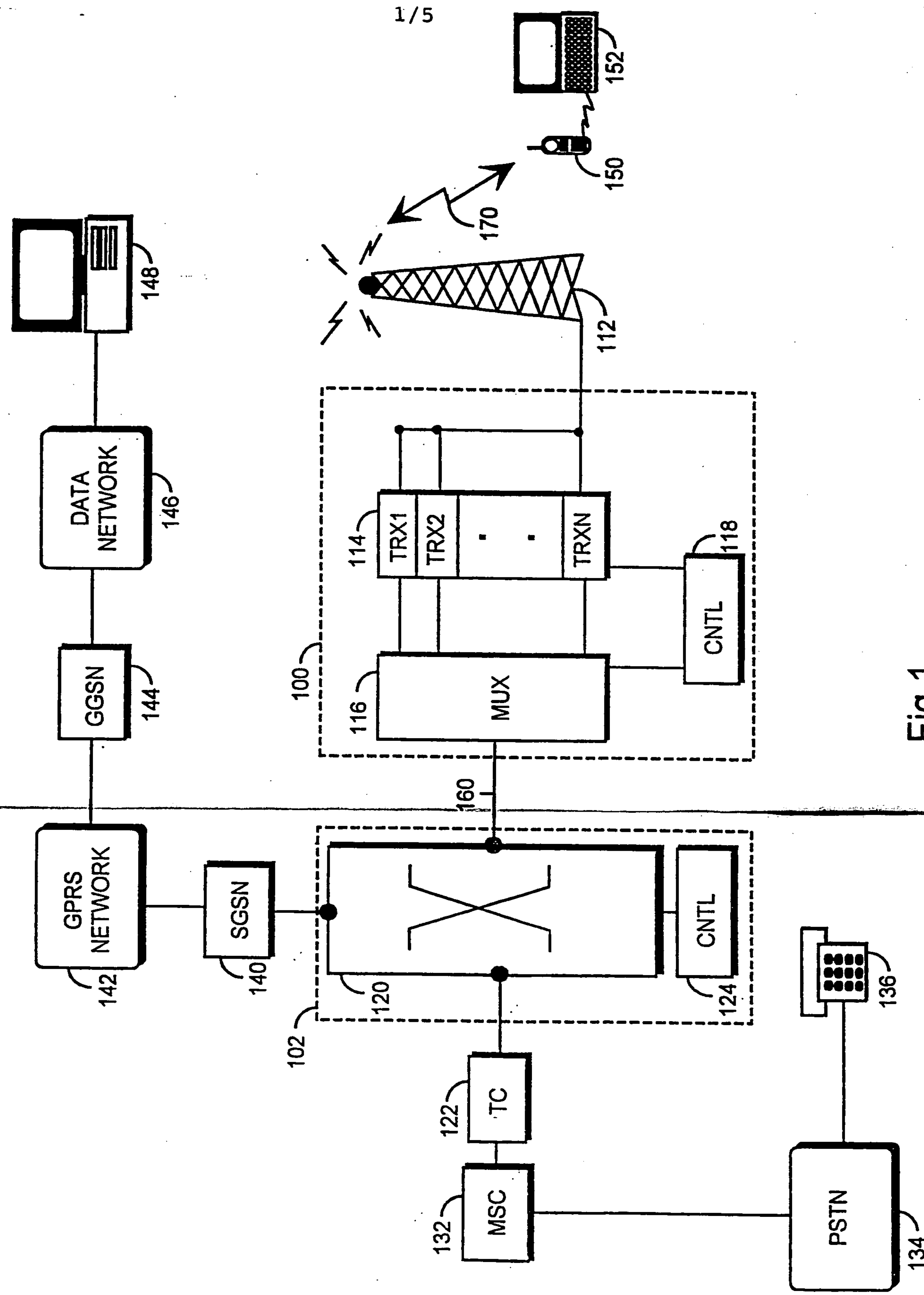
10. A base station system according to claim 8, **characterized** in that the base station system is arranged to carry out packet transmission by using GPRS (General Packet Radio Service).

11. A base station system according to claim 8, **characterized** in that the base station system is arranged to dynamically allocate the circuit-switched transmission connection (160) not in use in circuit-switched data transmission to the transmission of packet-switched data and packet-switched signalling.

12. A base station system according to claim 8, **characterized** in that the base station system is arranged to synchronize the transmission of packet-switched data and packet-switched signalling in both transmission directions by using a control loop of the circuit-switched transmission connection (160) between the base station (100) and the base station controller (102).

13. A base station system according to claim 9, **characterized** in that the base station system is arranged to transmit packet-switched data and packet-switched signalling by using frames of a standard TRAU structure.

14. A base station system according to claim 9, **characterized** in that the base station system is arranged to transmit packet-switched data and packet-switched signalling by using frames of an optimized structure.


152
150
170
148
DATA NETWORK
146
GGSN
144
GPRS NETWORK
142
SGSN
140
112
100
114
TRX1
TRX2
TRXN
118
CNTL
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MUX
160
102
120
CNTL
124
TC
122
MSC
132
PSTN
134
136

Fig 1

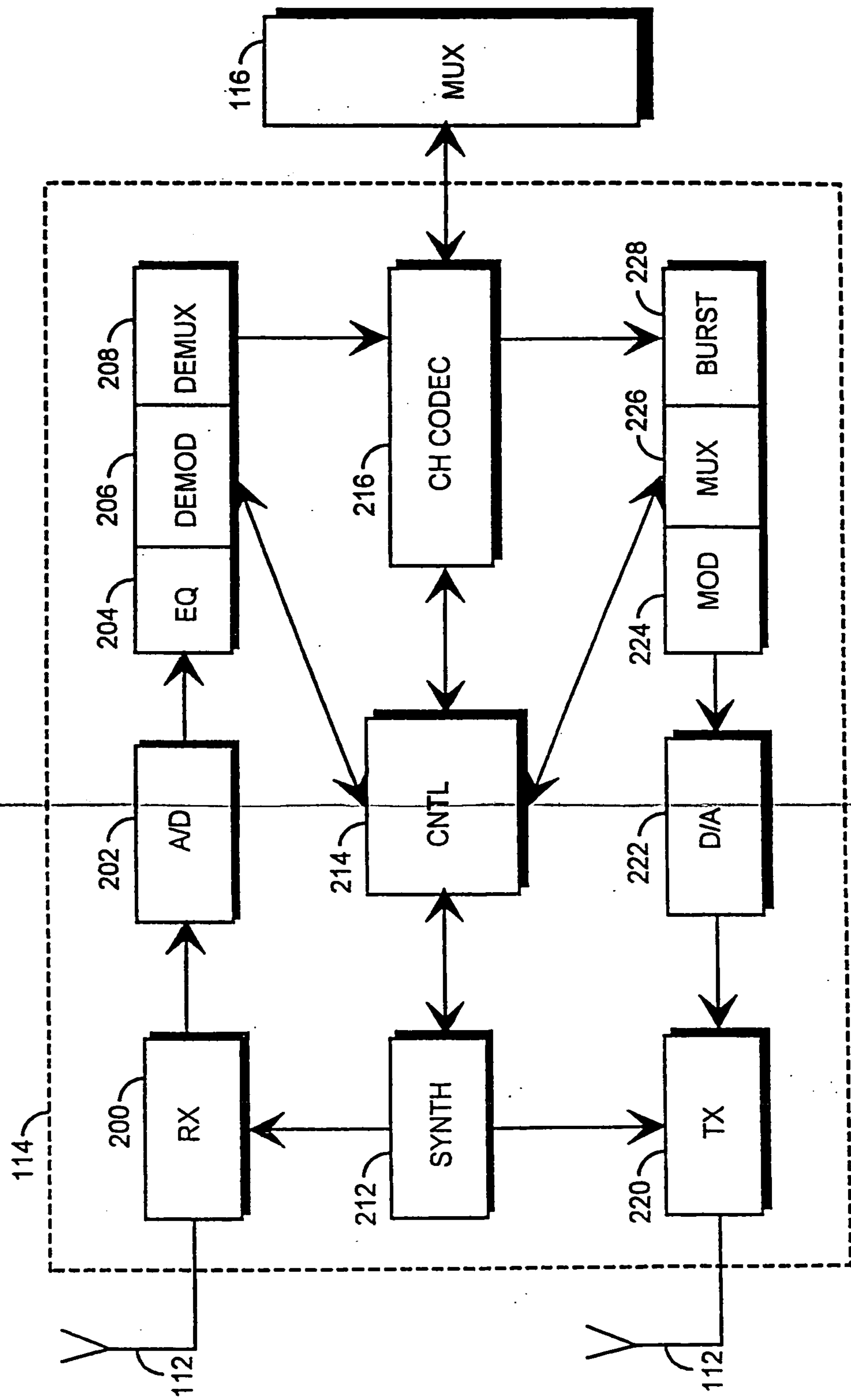

116
MUX
114
208
DEMUX
206
DEMOD
204
EQ
216
CH CODEC
228
BURST
226
MUX
224
MOD
202
A/D
214
CNTL
222
D/A
200
RX
212
SYNTH
220
TX
112
112

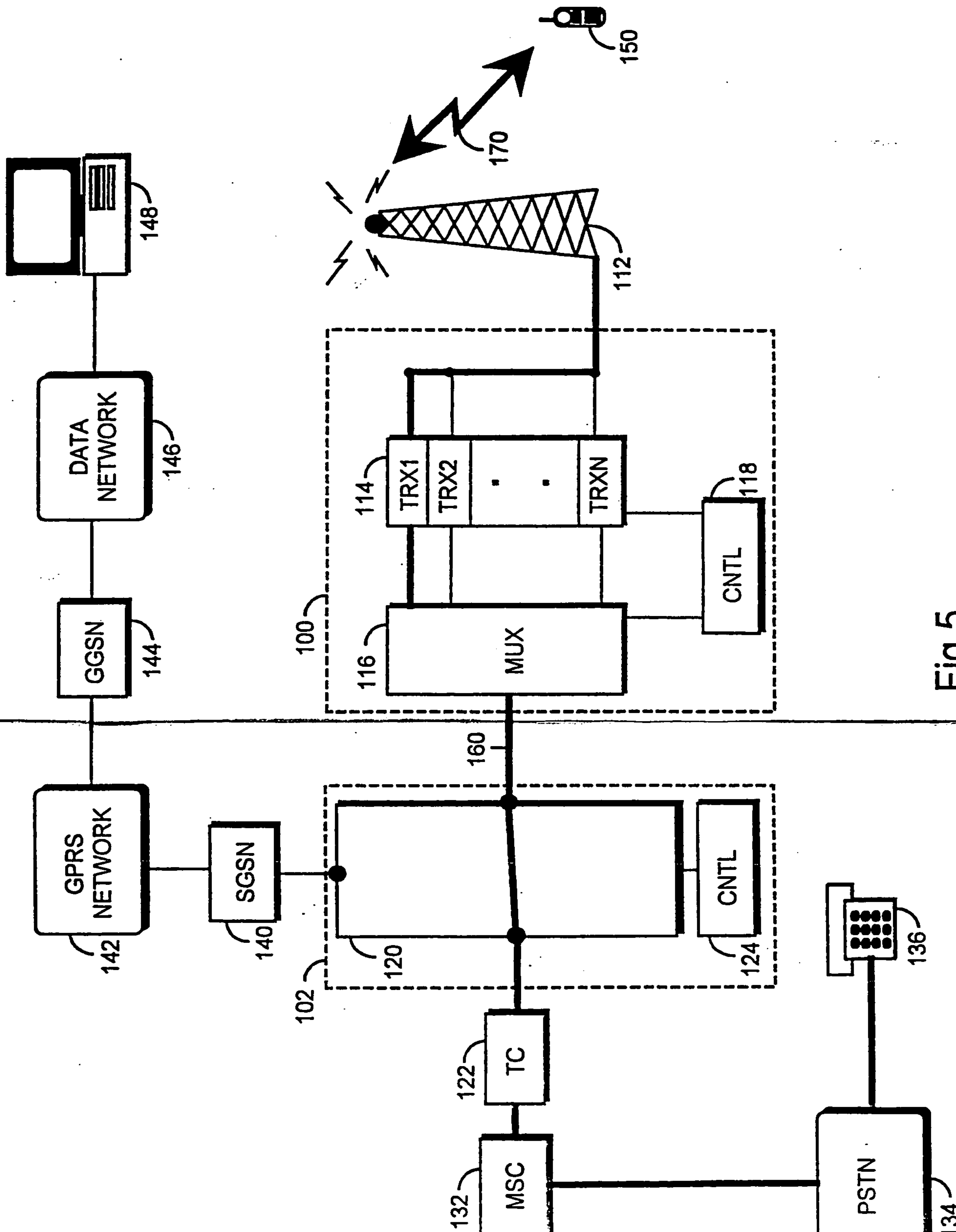
Fig 2

T0	T1	T2	T3	T4	T5	T6	T7
T0	T1	T2	T3	T4	T5	T6	T7
S1	S2						

Fig 3

W \ B	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	1
2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
3	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
5	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
7	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
8	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
9	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
10	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
11	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
12	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
13	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
14	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
15	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
16	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
17	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
18	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	1
19	T4	T3	T2	T1	C21	C20	C19	C18	C17	C16	P	P	P	P	P	1

Fig 4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146
114
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TRX2
TRXN
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CNTL
GGSN
144
100
116
MUX
160
GPRS NETWORK
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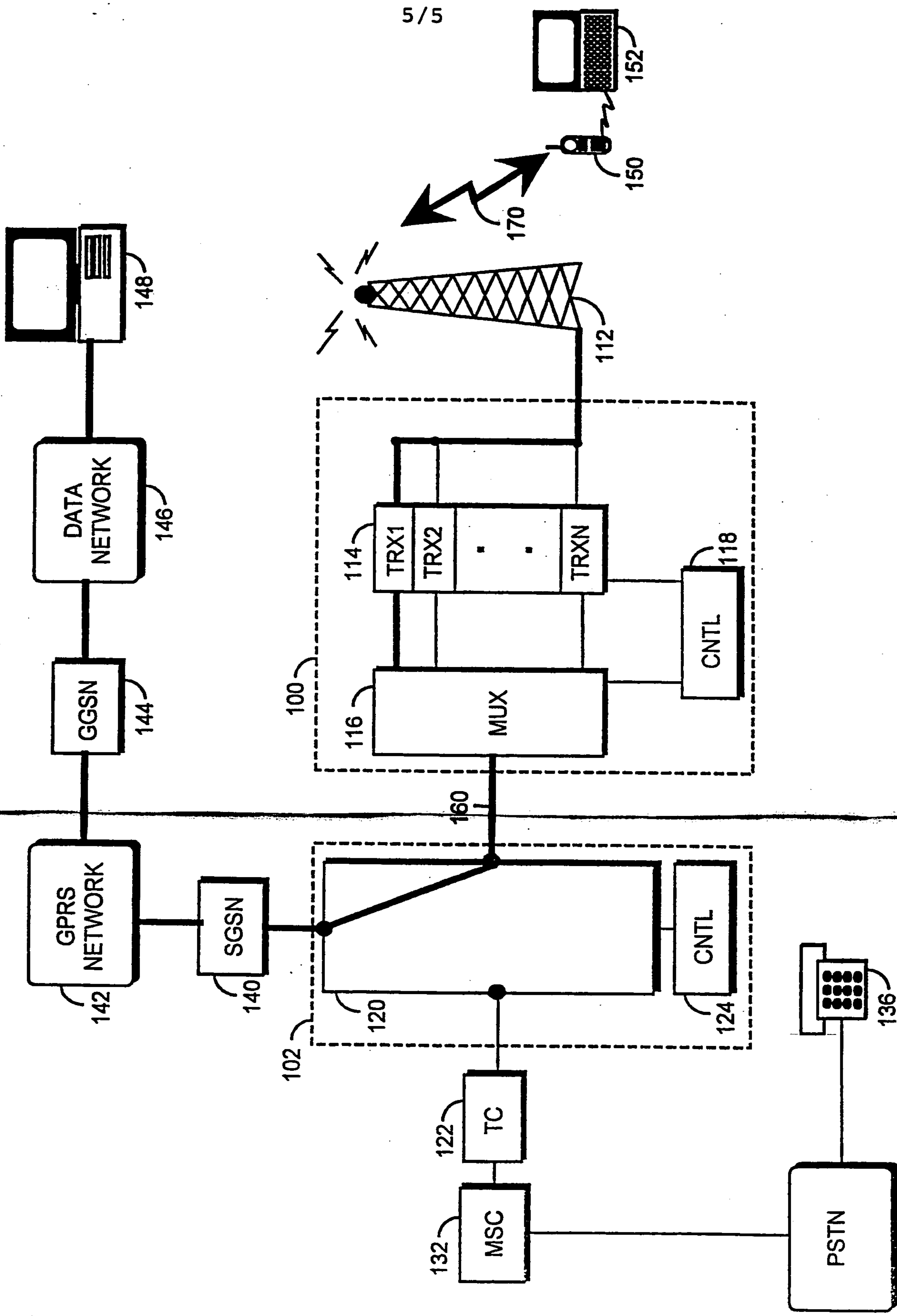
SGSN
140
120
CNTL
124
102
136
TC
122
MSC
132
PSTN
134

Fig 5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TRXN
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GPRS NETWORK
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Fig 6